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Socio-economic characterization of integrated cropping systems in urban and peri-urban agriculture of Faisalabad, Pakistan

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Abstract

Faisalabad city is surrounded by agricultural lands, where farmers are growing vegetables, grain crops, and fodder for auto-consumption and local marketing. To study the socioeconomic impact and resource use in these urban and peri-urban agricultural production (UPA) systems, a baseline survey was conducted during 2009–2010. A total of 140 households were selected using a stratified sampling method and interviewed with a structured questionnaire. The results revealed that 96 % of the households rely on agriculture as their main occupation. Thirty percent of the households were owners of the land and the rest cultivated either rented or sharecropped land. Most of the families (70 %) were headed by a member with primary education, and only 10 % of the household head had a secondary school certificate. Irrigation water was obtained from waste water (37 %), canals (27 %), and mixed alternative sources (36 %). A total of 35 species were cultivated in the UPA systems of which were 65 % vegetables, 15 % grain and fodder crops, and 5 % medicinal plants. Fifty-nine percent of the households cultivated wheat, mostly for auto-consumption. The 51 % of the respondents grew cauliflower (*Brassica oleracea* L.) and gourds (Cucurbitaceae) in the winter and summer seasons, respectively. Group marketing was uncommon and most of the farmers sold their produce at the farm gate (45 %) and on local markets (43 %). Seeds and fertilizers were available from commission agents and dealers on a credit basis with the obligation to pay by harvested produce. A major problem reported by the UPA farmers of Faisalabad was the scarcity of high quality irrigation water, especially during the hot dry summer months, in addition to lacking adequate quantities of mineral fertilizers and other inputs during sowing time. Half of the respondents estimated their daily income to be less than 1.25 US$ and spent almost half of it on food. Monthly average household income and expenses were 334 and 237 US$, respectively.

Keywords: mineral fertilizer, gardening, UPA household, vegetable production, waste water irrigation

1 Introduction

Pakistan's population grows at 3 % p.a. and is projected to increase from 139 million in 1998 to 208 million in 2025. By that time about half of the population will be urban (Government of Pakistan, 1998). The population of Faisalabad, the third largest city of Pakistan, grew 10-fold from 1951 (0.17 Mio) to 1998 (2 Mio) and is expected to reach 3 Mio in the near future (Scott *et al.*, 2007; City District Government, Faisalabad, 2010). Today Faisalabad covers an area of 5,856 km^2 out of which 1,280 km^2 is declared urban and peri-urban with open spaces for cultivation. About 2,139 ha land is irrigated with waste water (Kouser *et al.*, 2009). Similar urbanization is also witnessed in India, China, sub-

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Saharan Africa and other developing countries where urban and peri-urban agriculture (UPA) provides food and jobs to millions of habitants, triggers economic growth, and mitigates environmental pollution (Nguni & Mwila, 2007; Redwood, 2009). It was estimated that 10 % of the food requirement of the 700 million city dwellers worldwide are met by UPA (Schnitzler *et al.*, 1998). Moreover UPA makes a substantial contribution to alleviate poverty and in its multiple value chains allows to integrate old people, sick, handicapped, and uneducated young people producing fresh vegetables, fruits, and poultry by recycling waste water, organic municipal waste, and market refuse (Niang *et al.*, 2002; Cofie *et al.*, 2003).

The UPA farmers of Faisalabad cultivate vegetables, field crops and fodder that cover the growing demand of the city (Farkhanda *et al.*, 2009). Most farmers use a combination of canal water and untreated/partially treated waste water for irrigation. This is typical for Pakistan where only 1 % of the waste water is treated and the rest is directly used to irrigate an estimated total of 32,500 ha crop land, which has resulted in major pollution of streams (Ensink *et al.*, 2004; Anonymous, 2005; Murtaza *et al.*, 2008). The poorly quantified microbiological and heavy metal loads in many waste water have created widespread concern about food and environmental contamination. This study was part of a larger project aiming at characterizing UPA land use systems in Faisalabad to take more informed political decisions strengthening the socio-economic role of UPA (WHO, 1989; van der Hoek *et al.*, 2002) while minimizing negative externalities to the consumers and the environment.

2 Materials and methods

2.1 Study area

Faisalabad, located in the central part of the Punjab, lies between longitudes 73° to 74° east and latitudes 30° to 31.5° north with an altitude of 184 m asl. The dominant soil types are sand and silt loam, derived from alluvial deposits of the permanent rivers Ravi and Chenab coming from east and north (Muhammad *et al.*, 2008). The subtropical climate is characterized by an annual mean temperature of 24.5 °C and an unimodal monsoon-related total annual rainfall of 408 mm (Cheema *et al.*, 2006). Four seasons can be distinguished during the year: a winter season lasting from December to mid February with minimum temperatures of –1 °C, a spring from mid February to end March with an average of 15 °C, a long summer from April to mid September with maximum temperatures reaching up to 50 °C, and autumn from mid September to end of November with an average of 26 °C. This diverse climate is helpful to cultivate various kinds of crops.

Cotton (*Gossypium hirsutum* L.), wheat (*Triticum aestivum* L.), and sugarcane (*Saccharum officinale* L.) are the common crops cultivated around the city. These are complemented by UPA grown vegetables and fodder. An extensive canal system irrigates an estimated area of 580,000 ha (Government of Pakistan, 1998). In the western part of Faisalabad, around the Narwala and Jhang roads, farmers use mostly domestic sewage water for irrigation of their vegetable crops. The eastern side uses river water from the Rukh branch canal to grow vegetables and cereals, whereas cereal and fodder crops in the north and southern city region are irrigated with water from both sources (further referred to as “mixed water”).

There are two cropping seasons, winter and summer locally called ‘Rabi’ and ‘Kharif’, respectively. In the summer season, large areas remain uncultivated due to water shortage. During winter season, cauliflower (*Brassica oleracea* L.), berseem (*Trifolium alexandrinum* L.), and wheat are cultivated extensively. In summer, spinach (*Spinacia oleracea* L.) is the exclusive crop irrigated with waste water while gourds (cucurbits) predominate on the canal water irrigated lands. The typical annual cropping sequence in Faisalabad’s peri-urban areas is wheat – cotton and sugarcane – wheat, while cauliflower and spinach are most common at urban locations (Table 5).

2.2 Data collection

A baseline survey was conducted from August 2009 to March 2010 using a structured questionnaire. Farmers cultivating vegetables, grain crops, and fodder were interviewed. The farmers were selected after division of the city area into three zones differing in water resources and cropping systems (Figure 1). In zone one, vegetables are irrigated with river derived canal water. Farmers in zone two use domestic waste water for vegetables and fodder crops collected from municipal disposal units in the western part of the city. In zone three, cereals and fodders crops are irrigated with canal water in the winter and with waste water in the summer, and sometimes by mixed water. Within these three zones, a stratified sampling approached was used to select a total off 140 households (HH) within a radius of 3 to 12 km from the city center. HH selection was based on

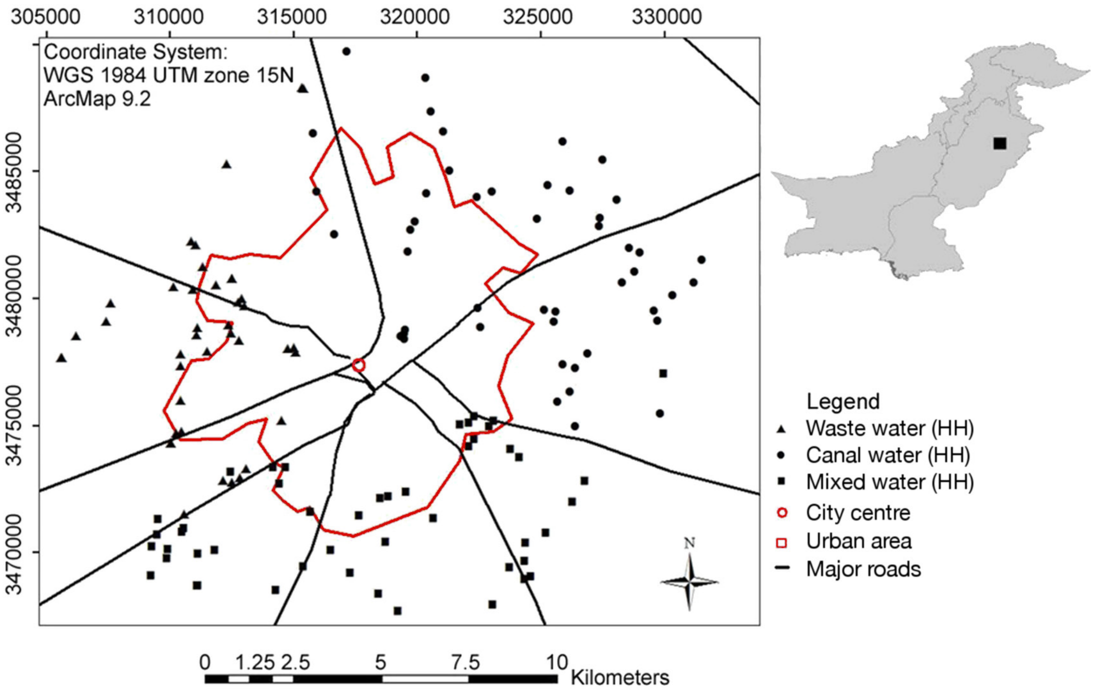

Fig. 1: *GIS-based map of Faisalabad (Pakistan) with the approximate expansion of the dense urban area (inside the polygon), major roads, city center, and position of interviewed household with waste water, canal water and mixed water use for their fields.*

the physical condition of the land, grower decision, and representative crops grown at the different locations of Faisalabad. At the end of interview the respondent was asked to indicate three other HHs nearby for the next interview (snow ball sampling). Of these three HHs, one was selected randomly and an appointment was fixed to conduct the interview. The geographical location of all interviewed HH was recorded with a Trimble Geoexplorer II GPS (Sunnnyvale, CA, USA) to allow mapping of HHs involved in the baseline study.

The questionnaire was designed to collect information on the biophysical and socioeconomic characteristics of UPA, land distribution, farmers' constraints, crops cultivated, and management of each farm.

2.2.1 *Data analysis*

Descriptive data analysis was conducted in Excel (Microsoft Office 2007). Differences between the production systems as affected by different sources of irrigation water were analysed with SPSS 17.0 (SPSS Inc. Chicago, IL, USA). As most of the data residuals were not distributed normally, the non-parametric Kolmogorov Smirnoff test was applied (Bortz *et al.*, 2008). The Kruskal-Walis-H-Test was used to detect significance differences among clusters using different variables and to create clusters.

3 Results

3.1 *Demographic characteristics*

Urban and peri-urban agricultural production in Faisalabad is exclusively under the responsibility of male family members and constitutes the main source of HH income. The majority (87 %) of UPA HH heads was married and 8 % had no formal education, 70 % primary education, 10 % secondary education, 8 % a BSc and 4 % a MSc (Table 1). The average size of the extended HHs was 7.5 members.

Eighty-one percent of the HHs had a UPA derived annual income of 1,200–6,000 US$, while only 14 % of the respondents had an annual UPA income > 6,000 US$ and 5 % of HHs < 1,200 US$ (Table 1). The 52 % of the HHs spent less than 2,400 US$ per year on living, food and utilities, while only 4 % spent > 6,000 US$. The most common sources of income were sale of agricultural products (vegetable, cereal, and fodder), hiring out of labour, extra-agricultural jobs, and small business activities.

Table 1: *Household characteristics of 140 interviewed urban and peri-urban production systems in Faisalabad, Pakistan during 2009–2010.*

HH characteristics	*Category*	*Frequency (n)*	*Percentage (%)*
Marital status	Married	121	87
	Single	15	11
	Widowed	3	2
	Divorced	1	1
Occupation	Agriculture	135	97
	Business	5	3
Education	Illiterate	11	8
	Primary	97	70
	Secondary	14	10
	Bachelor	12	8
	Master	6	4
Farm typology	WW* irrigated	52	37
	CW** irrigated	38	27
	MW*** irrigated	50	36
Average age of the HH head	≤ 25	8	6
	26–55	84	60
	> 55	48	34
Average age of family members	≤ 25	55	39
	26–55	60	43
	> 55	25	18
HH estimated monthly income (US$)	≤ 100	7	5
	101–200	38	27
	201–300	25	18
	301–500	50	36
	> 500	20	14
HH estimated monthly expenses (US$)	≤ 100	18	13
	101–200	57	41
	201–300	25	18
	301–500	35	24
	> 500	5	4

* Waste Water, ** Canal Water ***, Mixed Water

3.2 *Farm typology*

The three predominant UPA farming systems were (i) small scale farming with city waste water as an irrigation source (further referred to as ‘waste water’ irrigated; WW) accounting for 37 % of the HHs, (ii) medium scale farming with river-based canal water (further referred to as ‘canal water’ irrigated; CW; 27 %), and (iii) large scale farming with mixed water irrigation (MW; 36 %; Table 1).

Waste water HHs cultivated 2.14 ha (± 1.82 ha), CW HHs 3.32 ha (± 3.36 ha) and MW HHs 5.93 ha (± 8.76 ha). Almost half of the farmers cultivated their crops on rented land while 26 % in WW and 43 % in each CW and MW had their own land, respectively. In WW irrigated areas, 70 % of the HHs shared and rented land for their cultivation. In the CW system, almost equal numbers of HHs cultivated their own and rented land while only 15 % shared the land (Figure 2).

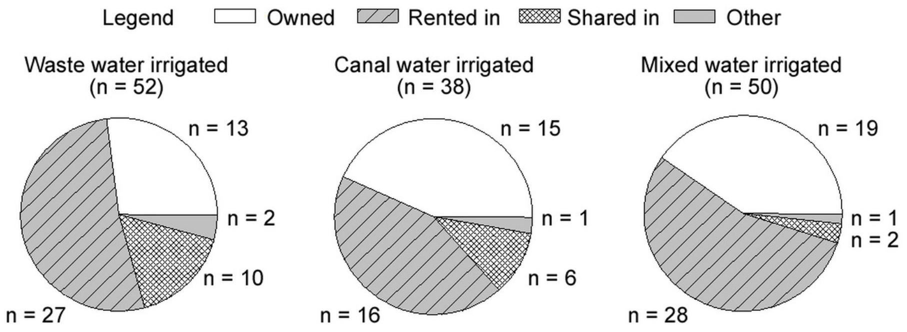

Fig. 2: *Land ownership characterization of urban and peri-urban plant production systems (n = 140) of Faisalabad, Pakistan during 2009–2010.*

Eighty-three percent, 73 % and 66 % of the farmers cultivated vegetables using waste water, canal water, and mixed water, respectively and 48–74 % of the HHs grew cereals, with the highest share in the mixed water system. Under WW, only 21 % of farmers cultivated fodder while in MW systems, fodder was grown by 43 % of the farmers. Almost half of the farmers in the MW systems reported growing also other crops such as sugarcane and medicinal plants (Figure 3).

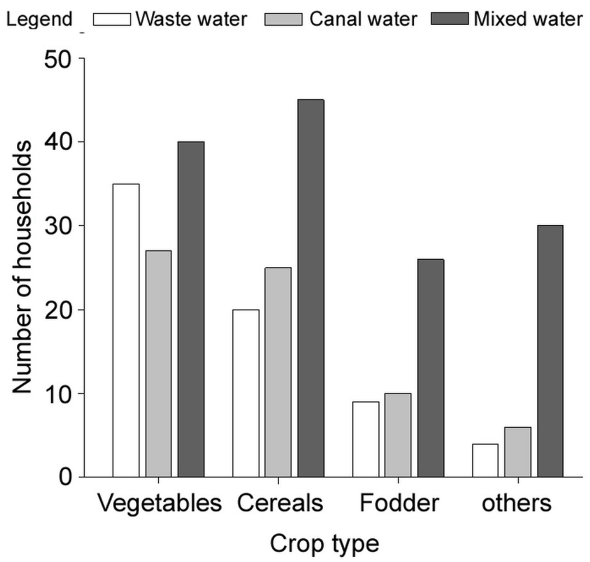

Fig. 3: *Major crop types grown under different irrigation systems in urban and peri-urban plant production systems (total number of households = 140) of Faisalabad, Pakistan, during 2009–2010.*

Cropping patterns significantly differed among the three irrigation systems. In WW and CW systems, vegetables predominated, while in MW systems cereals were prevalent. The 35 crops grown in UPA systems included summer and winter vegetables, cereal, fodder, and other crops in mixed cropping or monoculture. During the winter, the major vegetable crops grown were spinach (30 % respondents), cauliflower (29 %), radish (*Raphanus sativus* L.; 24 %), carrot (*Daucus carota* L.; 16 % respondents), and coriander (*Coriandrum sativum* L.; 14 % respondents). About two thirds of the farmers grew winter wheat while only 4 % grew oat (*Avena sativa* L.) for marketing. The main winter fodder cultivated was berseem (25 % of farmers; Figure 4).

During the summer season, mainly bottle gourd (*Lagenaria siceraria*), brinjal (*Solanum melongena* L.), tomato (*Lycopersicon esculentum* Mill.), sponggourd (*Luffa actangula* L.), and vegetable marrow (*Cucurbita pepo*) were grown by 9 %, 9 %, 8 %, 7 %, and 5 % of farmers, respectively. Maize and rice were the two main summer cereals grown by farmers as reported by 17 % and 6 % of the respondents. About 21 % of the farmers were growing sorghum (*Sorghum bicolor* L.) and 7 % millet (*Pennisetum glaucum* L.) for fodder during the summer season (Figure 4). Overall winter crops were more important than summer crops.

3.3 Agricultural practices

Farmers used organic and chemical fertilizers regardless of irrigation type. Only half of the WW farmers applied farm yard manure (FYM) from buffalo colony or waste collected from animal keepers in peri-urban areas as compared to 94 % and 79 % of farmers from canal and mixed water irrigation systems, respectively (Table 2). The quantity of FYM applied by CW farmers was about 5 t DM ha^{-1} yr^{-1} which was twice as high as the average FYM application rate in the other two systems. The major fertilizer applied to soil was diammonium phosphate (DAP) as used by 29–69 % of the farmers across systems. The majority (78–100 %) of farmers used top-dressed urea during the vegetative phase of crop production (Table 2).

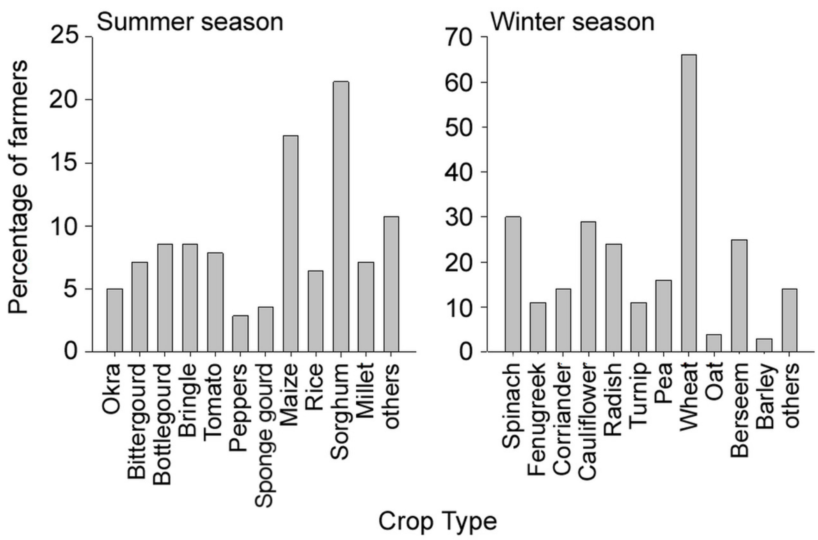

Fig. 4: *Major crops grown in urban and peri-urban plant production systems of Faisalabad, Pakistan, during 2009–2010.*

Table 2: *Fertilizer use in urban and peri-urban plant production systems of Faisalabad, Pakistan during 2009–2010.*

			Soil application						
HH irrigation type	*HH share (n)*		*FYM*	*Urea*	*DAP*	*NP*	*SSP*	*Others*	*Urea**
Waste water	52	% of HHs	50	11	29	3	7	0	78
		Avg. amount (kg DM ha^{-1})	2,516	9	24	6	3	0	120
Canal water	38	% of HHs	94	6	43	19	0	0	100
		Avg. amount (kg DM ha^{-1})	4,927	4	29	14	0	0	146
Mixed water	50	% of HHs	79	10	69	13	2	2	98
		Avg. amount (kg DM ha^{-1})	2,510	4	33	10	2	1	93

FYM: Farm Yard Manure, DAP: Di-Ammonium Phosphate, NP: Nitro-Phosphate, SSP: Single Super Phosphate *top dressed.

Table 3: *Plant protection measures (annual average) in urban and peri-urban plant production systems of Faisalabad, Pakistan during 2009–2010.*

HH irrigation type	*HH share (n)*		*Weeding*		*Chemical Plant protection*
			Manual	*Chemical*	
Waste water	52	% of HHs	69	7	90
		Applications yr^{-1}	17	1	4
Canal water	38	% of HHs	54	6	70
		Applications yr^{-1}	14	1	3
Mixed water	50	% of HHs	51	60	83
		Applications yr^{-1}	21	2	3

Weeding was carried out manually by 29 % of the WW and 20 % of CW farmers, respectively. Only 3 % of WW and 2 % of CW farmers used herbicides once per year. In MW systems, half of the interviewed farmers responded that they were weeding their fields manually 19-times per year, while 60 % of farmers used chemical herbicides twice a year (Table 3). In the WW irrigation system an average number of 17 labourers were employed each year for weeding, while in CW 54 % of HHs used on average 14 labourers per farm throughout the year. About 70 % to 90 % of the HHs confirmed the use of pesticides for plant protection 3–4 times a year (Table 3).

Fertilization involved the highest agricultural management costs (112–194 US$ ha^{-1} yr^{-1}). Annual costs of organic fertilizer in CW systems were 394 US$ ha^{-1}. Manual weeding costs were < 42 US$ ha^{-1} yr^{-1} in any irrigation system while maximum annual costs for chemical plant protection amounted to 19 US$ ha^{-1} (Figure 5).

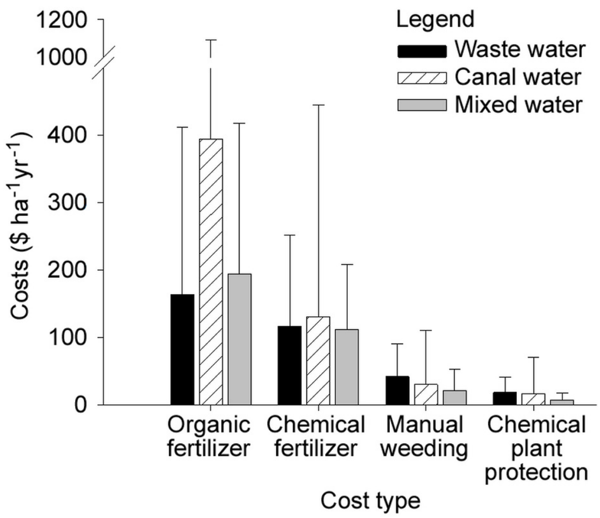

Fig. 5: *Cost of management practices (in US$) estimated by farmers in urban and peri-urban plant production systems of Faisalabad, Pakistan during 2009–2010.*

Table 4: *Marketing in urban and peri-urban plant production systems of Faisalabad, Pakistan during 2009–2010.*

	Grading		*Storage*	
	Yes	*No*	*Yes*	*No*
% of HHs	44	56	92	8
No. of HHs	62	78	129	11
		Packing material		
	None	*PE* bags*	*Wooden material*	*Jute bags*
% of HHs	26	57	14	3
No. of HHs	37	80	19	4
		Transport of the produce		
	Animal-driven cart	*Tractor*	*Truck*	*Others*
% of HHs	59	34	3	4
No. of HHs	83	48	4	5
		Yield selling place		
	At the farm gate	*Local market*	*City market*	*Others*
% of HHs	45	43	8	4
No. of HHs	63	60	11	6
		Buying client		
	Consumer	*Commission agent*	*Retailer*	*Wholesaler*
% of HHs	23	53	16	8
No. of HHs	33	74	22	11

* Polyethylene

3.4 Product handling and marketing

The agricultural product handling and sales comprised an array of crop-specific activities. Product grading (sorting for quality) was important in 44 % of the HHs, particularly in vegetables, which were sold mostly fresh, without processing. Most farmers (92 %) stored their cereals at home for auto-consumption and sold only a small part of their harvest off-season when prices were high. Polyethylene, jute bags or wooden boxes were used to pack the different commodities. About 26 % of farmer's did not use any packing material for fresh vegetables (Table 4). In 59 % of the cases, farmers used animal-driven carts to transport their goods to the selling point, while a third used tractors. Most farmers sold their produce directly at the farm gate (45 %) or on a local market (43 %), mostly to a commission agent (53 %). Only 23 percent of farmers sold their produce directly to the consumer (Table 4).

3.5 Farmers' problems

Most farmer problems were closely related to finances, fertilizer costs and their availability at the sowing time, labour availability, the quality and quantity of seed, and to water availability, especially during the summer season. More than two thirds of the farmers complained about high cost of fertilizers, other agrochemicals, and man power. For 61 % of the respondents water scarcity was an important production constraint while seed quality and availability were considered as less important problems by almost 80 % of farmers because most of the farmers used their own seed or took it from other farmers within the community (Figure 6).

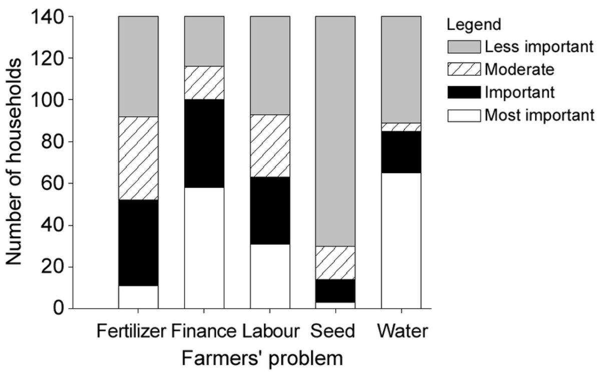

Fig. 6: *Major problem experienced by UPA farmers in urban and peri-urban plant production systems of Faisalabad, Pakistan, during 2009–2010.*

4 Discussion

The current average farm size in Faisalabad's UPA was with 7.4 ha lower than the figure given by the Census Survey of the Government of Pakistan in 1988. On the other hand, average household size in the UPA system in Faisalabad exceeded those reported by Shrinivasan (2012) and Sahar (2012) for urban areas of India and Sudan (4 and 6.3 members / UPA household, respectively). This is mainly due to the extended family system prevailing in the Pakistani society. The HH heads in our study were exclusively male as also reported by Hagmann (2012), who found that 99.3 % of farm HHs were headed by males. The educational level among the HH heads of UPA farming families showed that almost two thirds had completed five years and one third more than ten years of education. This pattern is similar to that reported by Javed *et al.* (2008) who concluded that 82 % and 18 % of respondents in Faisalabad reached five and ten years of education, respectively.

The cropping pattern differed between urban and peri-urban areas, however, the share of land allocated to the crops reflected the distance to local markets. While urban farming focus on vegetables, peri-urban and rural areas produce grain and fodder. A total of 35 crop species were grown by the farmers (Table 5). A majority of HHs engaged in cereal production, retained them for home consumption. Similar results on crop distribution were reported by Baig *et al.* (2011) for Faisalabad where about 50 % area was reserved for wheat cultivation. In Sudan (Sahar, 2012) and India (Jacobi *et al.*, 2009) the majority of urban HHs preferred short duration crops such as leafy vegetables to obtain high profits per unit area as compared to grain crops in peri-urban areas.

The diversity of vegetables grown was large which supported similar results of Ogungbile *et al.* (1998) from Nigeria and of Jacobi *et al.* (2009) from Hyderabad, India where farmers grow different vegetables to avoid low prices during the glut period. Spinach (*Spinacia oleracea* L.) and cauliflower were dominant crops cultivated on vast UPA areas whereby the former is cultivated under waste water irrigation throughout the year. Production of these crops in Faisalabad was also reported by Kouser *et al.* (2009) and Weckenbrock (2010). As waste water is rich in plant nutrients, lower amounts of mineral fertilizers are required as observed by Kouser *et al.* (2009) in Faisalabad and Ensink *et al.* (2007) in Haroonabad, Pakistan. Our data (Table 2) support this as smaller amounts of manure were applied in fields where waste water was the main source of irrigation. The rate of FYM in CW systems was similar to that recommended by Malik (1994). Our findings also support those of Ensink *et al.* (2002) and Baig *et al.* (2011) in Faisalabad. Both papers concluded that the application of mineral fertilizers in CW irrigation systems was almost twice and even in some cases thrice as high as in WW systems and that the frequency of top dressing of urea was higher in CW systems. Drechsel *et al.* (2005) found in West African UPA systems that the amount of fertilizer used in urban farming was much higher than in other systems. However, the magnitude of fertilizer application varied across different crops with vegetables receiving higher quantities than cereals. Similar findings were also reported by Ensink *et al.* (2004) and Scott *et al.* (2007) from South Asia who confirmed that nutrient rich waste water is used by farmers mainly because of its ready availability and the possibility to reduce the use of nutrient inputs. Expenses for nutrient inputs per HH were also higher in CW than in WW systems (Figure 5).

In urban areas of Faisalabad FYM is scarce as the city administration has banned large animals from the city and made them transfer to milking colonies in the peri-urban space. Urban farmers therefore had difficulties to access FYM which they only applied once a year. Hagmann (2012) and Raja (2002) reported that 40 % of the HHs dispose of their animal excreta which are later sold to farmers as a fertilizer.

Almost half of the respondents graded their commodities to obtain higher market prices. Fodder and leafy vegetables were marketed without packing while only 3 % of the HHs used jute bags for cereals as these are expensive. As a particularly perishable vegetable, tomato was marketed in wooden crates and boxes of 15–25 kg capacity similar to those in Hyderabad, India (Mari, 2009) and Cambodia (Buntong *et al.*, 2012). This allows to minimize post-harvest losses which may reach 30 % and directly affect producer income (Malik, 1991; Nicola *et al.*, 2006).

Multipurpose animal-driven carts serve short-distance marketing of UPA produce, but more distant marketing requires trucks and tractors. Commission agents are influential in auctioning the produce which is what > 50 % of the respondents do. In Sindh province of Pakistan Mari (2009) reported this kind of marketing system which encompasses the supply chain from the field to the doorstep of consumers. Other middlemen who affect the marketing channels were retailers, wholesalers, and consumers who took their share both from producers and consumers. A 100 % price difference was observed between sales and purchasing prices.

Table 5: *Selected plant species cultivated by UPA farmers during 2009–2010.*

Comman name	*Botanical name*	*Family*
Barley	*Hordeum vulgare* L.	Poaceae
Beans	*Vigna sinensis* S.	Fabaceae
Berseem	*Trifolium alexandrinum* L.	Fabaceae
Bitter gourd	*Momordica charantia* L.	Cucurbitaceae
Bottle gourd	*Lagenaria sicerarta* M.	Cucurbitaceae
Bringle	*Solanum melongena* L.	Solanaceae
Cabbage	*Brassica oleracea* L. var. *capitata*	Brassicaceae
Carrot	*Daucus carota* L.	Apiaceae
Cauliflower	*Brassica oleracea* L. var. *botrytis*	Brassicaceae
Chilli	*Capsicum frutescens* L.	Solanaceae
Coriander	*Coriandrum sativum* L.	Apiaceae
Cotton	*Gossypium hirsutum* L.	Malvaceae
Cucumber	*Cucumis sativus* L.	Cucurbitaceae
Fenugreek	*Trigonella foenum-graecum* L.	Fabaceae
Garlic	*Allium sativum* L.	Amaryllidaceae
Maize	*Zea mays* L.	Poaceae
Melon	*Cucumis melo* L.	Cucurbitaceae
Millet	*Pennisetum glaucum* L.	Poaceae
Okra	*Abelmoschus esculentus* L.	Malvaceae
Onion	*Allium cepa* L.	Amaryllidaceae
Pea	*Pisum sativum* L.	Fabaceae
Radish	*Raphanus sativus* L.	Brassicaceae
Rice	*Oryza sativa* L.	Poaceae
Sorghum	*Sorghum bicolor* L.	Poaceae
Spinach	*Spinacia oleracea* L.	Amaranthaceae
Sponge gourd	*Luffa acutangula* R.	Cucurbitaceae
Squash	*Citrullus vulgaris* L.	Cucurbitaceae
Sugarcane	*Saccharum officinarum* L.	Poaceae
Sweet paper	*Capsicum annum* L.	Solanaceae
Sweet potato	*Ipomoea batatas* L.	Convolvulaceae
Tobacco	*Nicotiana tabacum* L.	Solanaceae
Tomato	*Lycopersicon esculentum* M.	Solanaceae
Turmeric	*Curouma longa* L.	Zingiberaceae
Turnip	*Brassica rapa* L.	Brassicaceae
Wheat	*Triticum aestivum* L.	Poaceae

About 76 % of the respondents felt that financial constraints prevented them from buying agricultural inputs (particularly mineral fertilizers) to enhance their yields. More than half of the area remained uncultivated during the summer season in CW and MW areas due to a shortage of water as reported by Kouser *et al.* (2009). Sixty-three percent of the respondents were facing shortages of irrigation water despite the availability of waste water (WW). Shortage of water, mineral fertilizers, and the monopoly of commission agents (to obtain loans for crop production) especially at sowing time delayed sowing and as a result yields remained low, particularly for cereals.

5 Conclusions

The low level of education may hamper the adoption of farm innovations in the study area. With respect to input cost and returns, the use of WW had distinct advantages over CW and MW irrigation systems. Spinach and cauliflower were exclusively cultivated with WW while gourds and sugarcane were the main crops cultivated with CW and MW irrigation systems. Year-round supply of irrigation water and low input use resulted in reduced costs of production and an increase in net returns. The current focus of UPA farmers is on quantity, not quality. This is evidenced by the fact that < 50 % of the respondents had adopted grading practices in view of a lacking storage facility for fresh commodities. UPA vegetable farmers reaped higher returns per unit area compared to those growing cereal, fodder, and others crops. Crop intensity and diversity were higher in the winter season, while in summer more than half of the area remained uncultivated due to severe shortages in irrigation water.

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